

# Intraseasonal to Seasonal Forecasting of Tropical Cyclone Formations: Comparison of Model Results using both CFSv1 and CFSv2 Forcing

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**Typhoons Tembin (15W)  
and Bolaven (16W)  
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37th CDPW, 30Oct12, [murphree@nps.edu](mailto:murphree@nps.edu)



# Quick Look at TC Formation Forecasting skill Using CFSv1 and CFSv2 Forcing of Statistical Models

Using a CFSv2 driven forecasting system shows significant improvement in many ways:

1. In side by side comparison for 2011 using both inputs we found:
  - a) For roughly equivalent skill, CFSv2 captures formations with a 25% reduction of the area of a CFSv1 driven forecast (weekly forecasts)
  - b) Less ensembling required to get skillful forecasts (large reduction in processing time)
  - c) For daily forecasts, CFSv2 forecasts were typically slightly more skilled
2. Other observations:
  - a) CFSv2 normally good at capturing the effects of the MJO at a 2 week lead
  - b) Anecdotal evidence that it captures the effects of smaller scale, lower frequency events such as Kelvin waves and equatorial Rossby waves
  - c) Clear evidence *CFSv1* correctly captures the effects of ENSO months in advance
  - d) The CFSR based model has much improved year round performance

**But are CFS driven forecasts of TC formation even skillful?**



# Forecasting of Tropical Cyclogenesis in the Western North Pacific

## NPS Statistical-Dynamical Forecast Method

**Build** statistical model based on relationships between TC formations and LSEFs\*\* (based on JTWC best track and NCEP R2/CFSR data)

**Apply** statistical model of TC formation probability (NPS logistic regression model)

**Produce** statistical-dynamical model output: ensemble-based long range forecasts of TC formation probabilities (NPS TC LRFs, 0-90 day lead times)

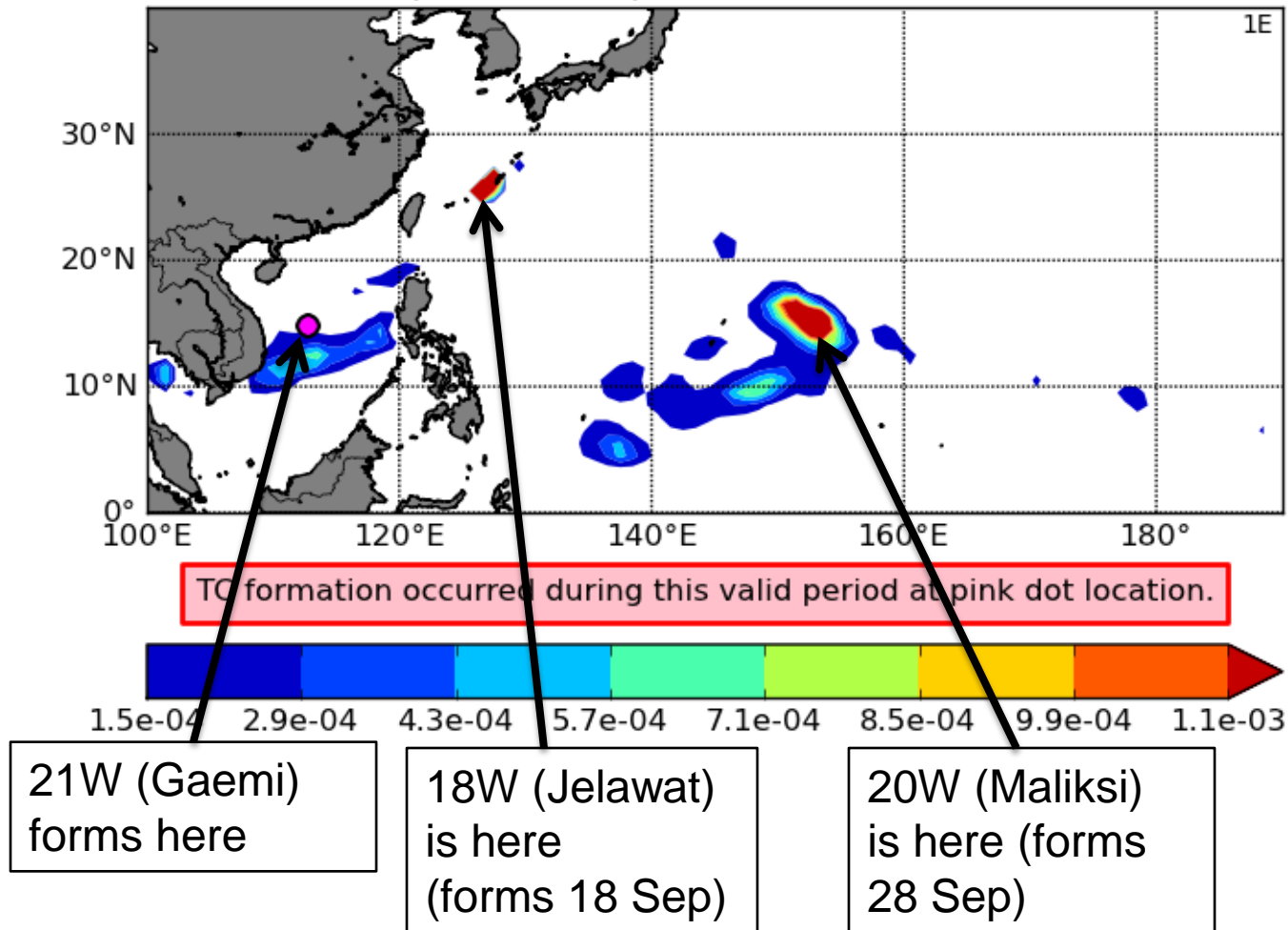
**Force** statistical model with dynamical, ensemble-based, long range forecasts of LSEFs\*\* (use NCEP Climate Forecast System v1/v2)

- \*\* LSEFs = large scale environmental factors: SST,  $\zeta_{850}$ , shear<sub>200-850</sub>, div<sub>200</sub>,  $f$**
- 1. Statistical model used with CFSv2 input is different from the previous model**
  - 2. LSEFs (Gray – 1975) are necessary but not sufficient for TC formation**



# 1 Day Lead Forecast of TC Formation Probability

Hit: 21W, 1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20120928, valid:20120929



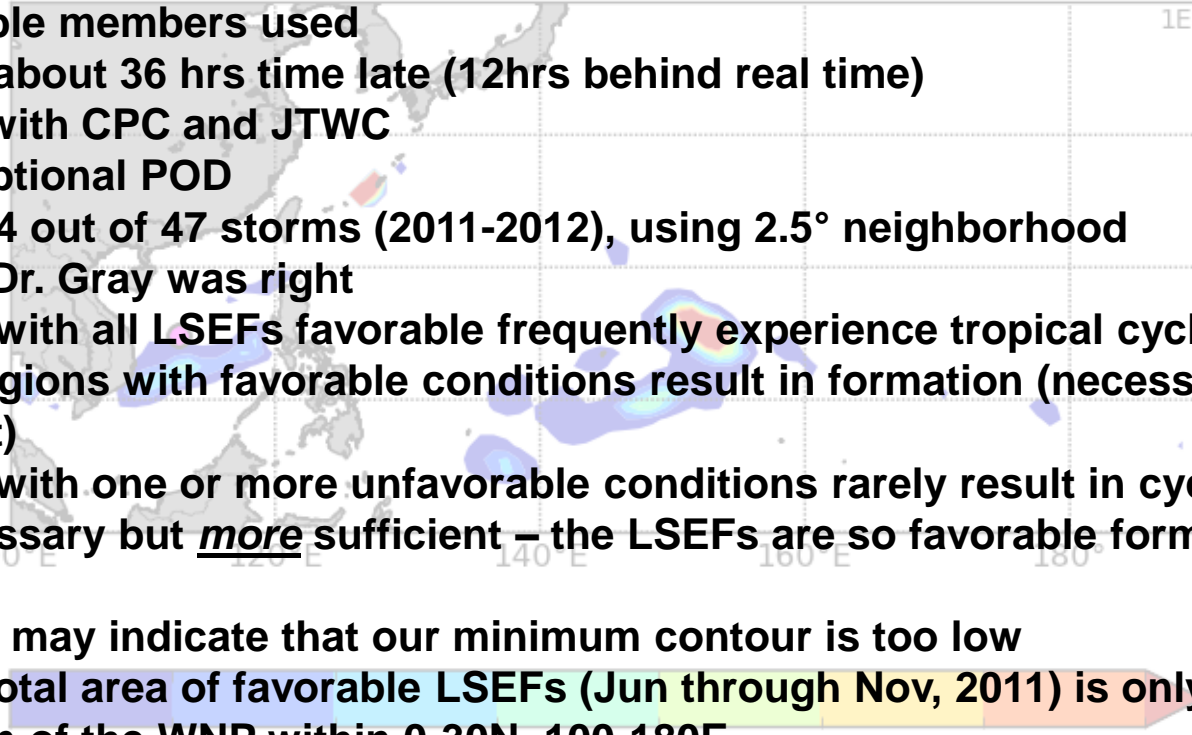




# 1 Day Lead Forecasts of TC Formation Probability

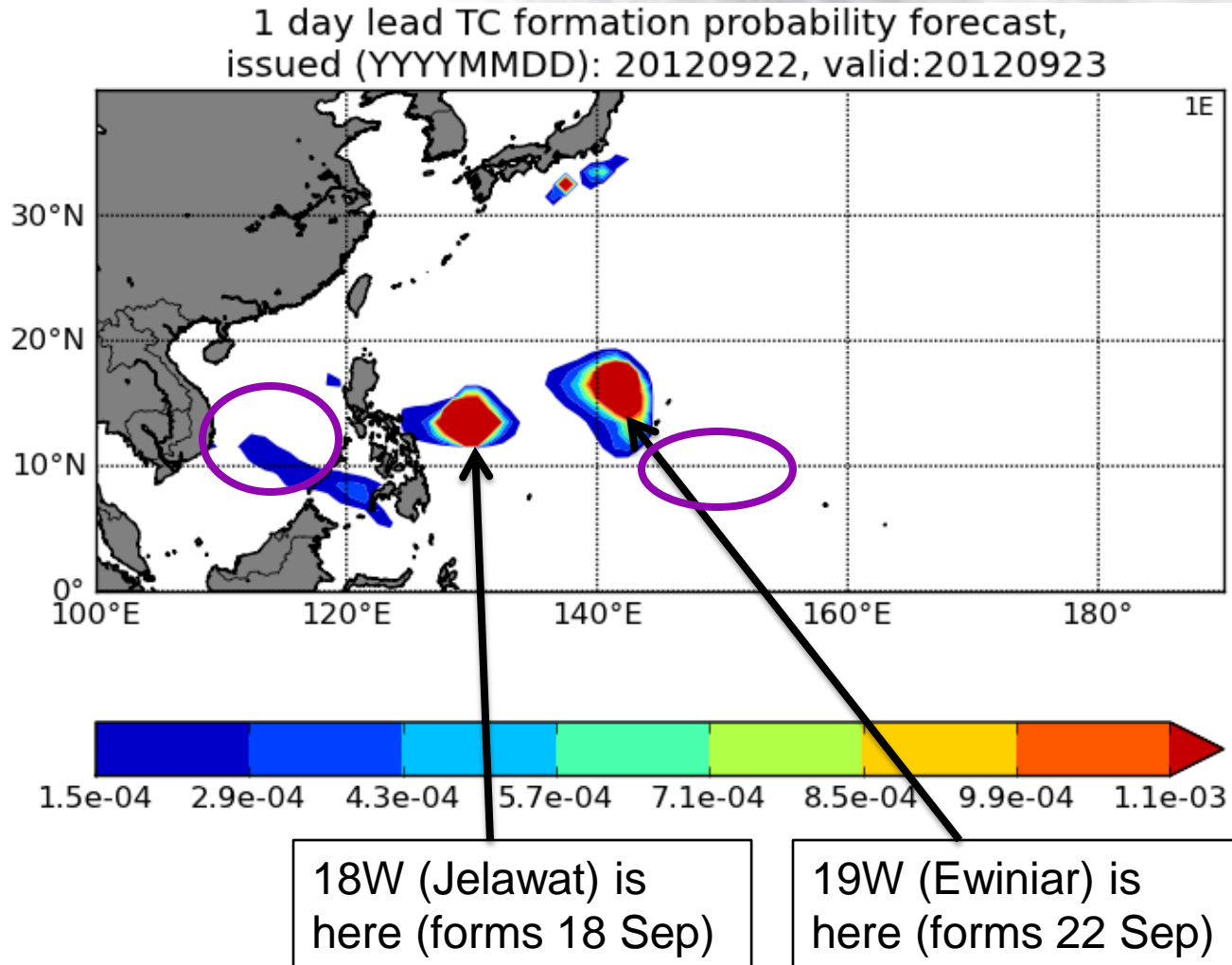
One day lead forecasts:

1. Uses the four daily (00, 06, 12...) CFSv2 24 lead forecasts of the LSEFs
  - a) 4 ensemble members used
  - b) Actually about 36 hrs time late (12hrs behind real time)
2. Shared daily with CPC and JTWC
3. Have an exceptional POD
  - a) Hits on 44 out of 47 storms (2011-2012), using 2.5° neighborhood
4. Suggest that Dr. Gray was right
  - a) Regions with all LSEFs favorable frequently experience tropical cyclogenesis
  - b) Not all regions with favorable conditions result in formation (necessary but not sufficient)
  - c) Regions with one or more unfavorable conditions rarely result in cyclogenesis
5. Suggest necessary but more sufficient – the LSEFs are so favorable formation is a near certainty
  - a) This also may indicate that our minimum contour is too low
6. The average total area of favorable LSEFs (Jun through Nov, 2011) is only 3.6% of the marine portion of the WNP within 0-30N, 100-180E
7. Highlight the ambiguity over when exactly cyclogenesis occurs.
  - a) Favorable, even strongly favorable conditions may be forecasted before the first JTWC TCFA or best track initial point
  - b) Conditions post formation often little changed compared to conditions prior to formation
8. All forecasts are objective and fully automated





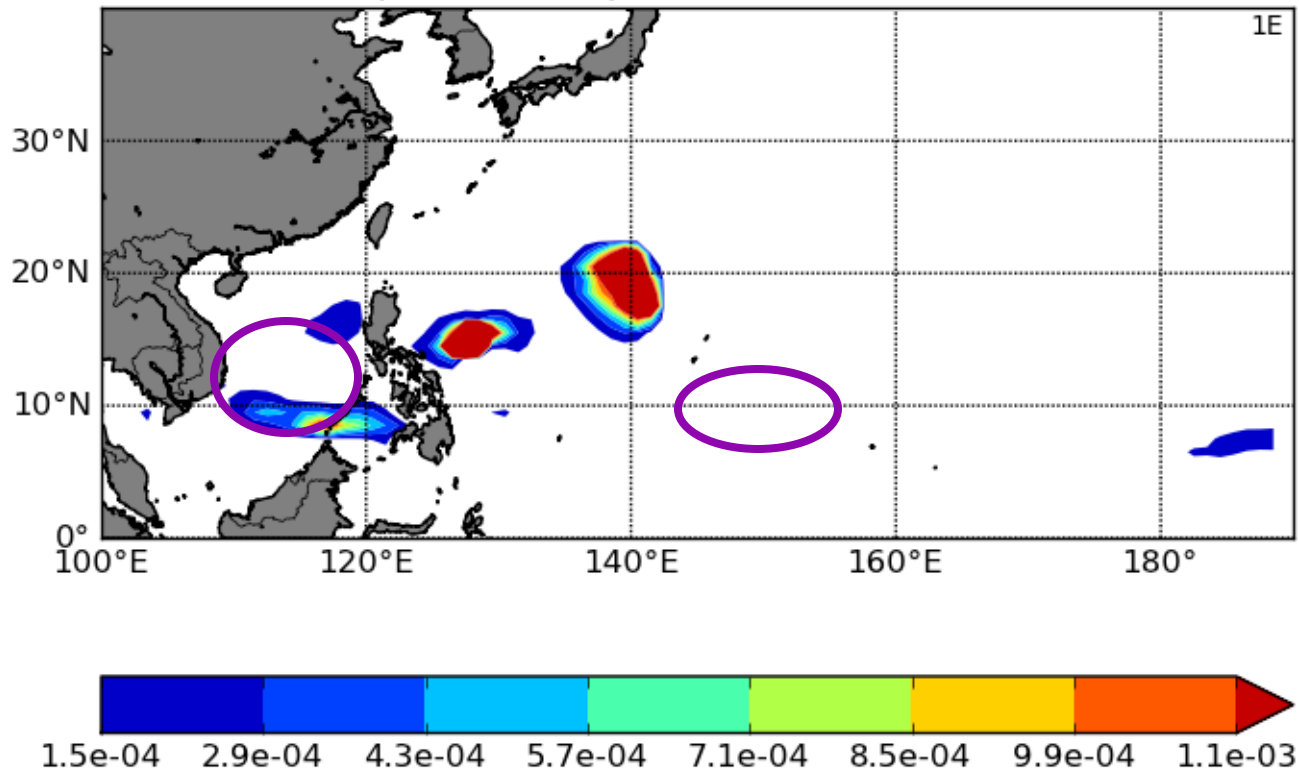
# Multi-Day Lead Information From 1 Day Lead Forecasts





# Multi-Day Lead Information From 1 Day Lead Forecasts

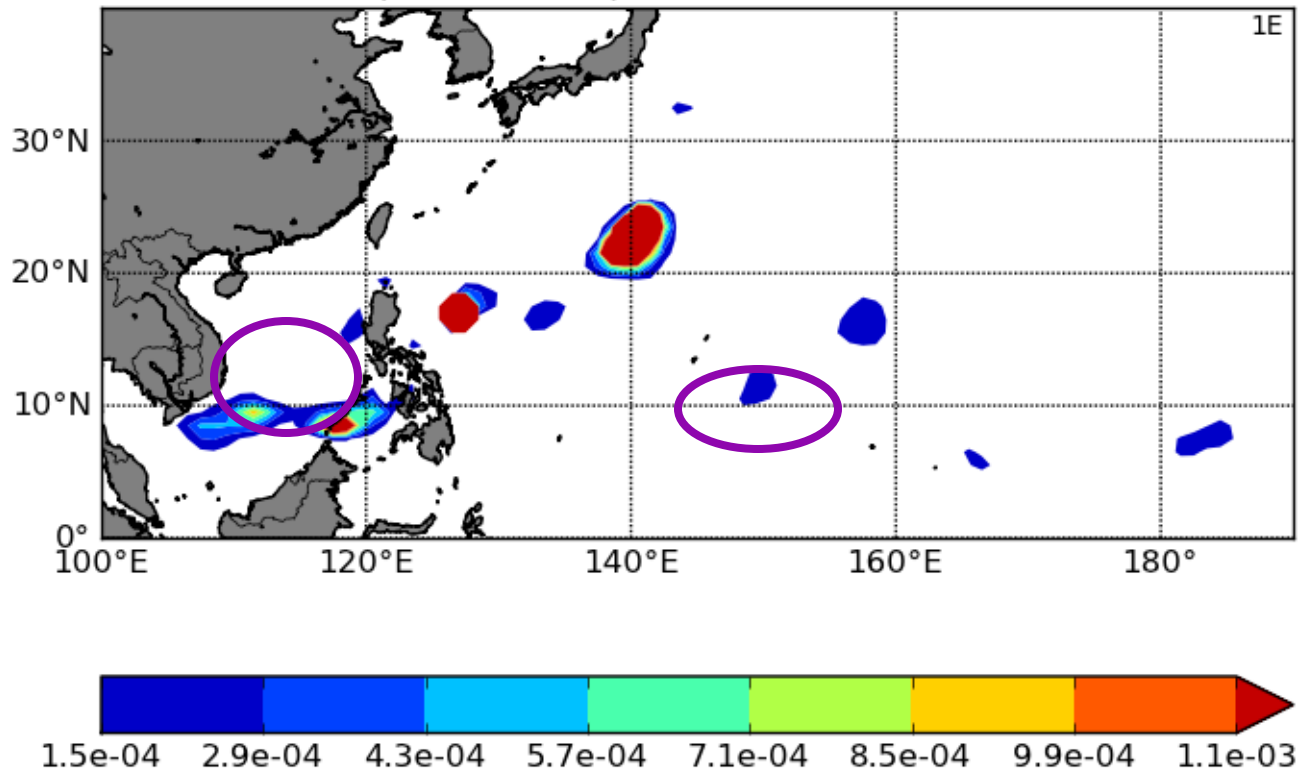
1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20120923, valid:20120924





# Multi-Day Lead Information From 1 Day Lead Forecasts

1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20120924, valid:20120925

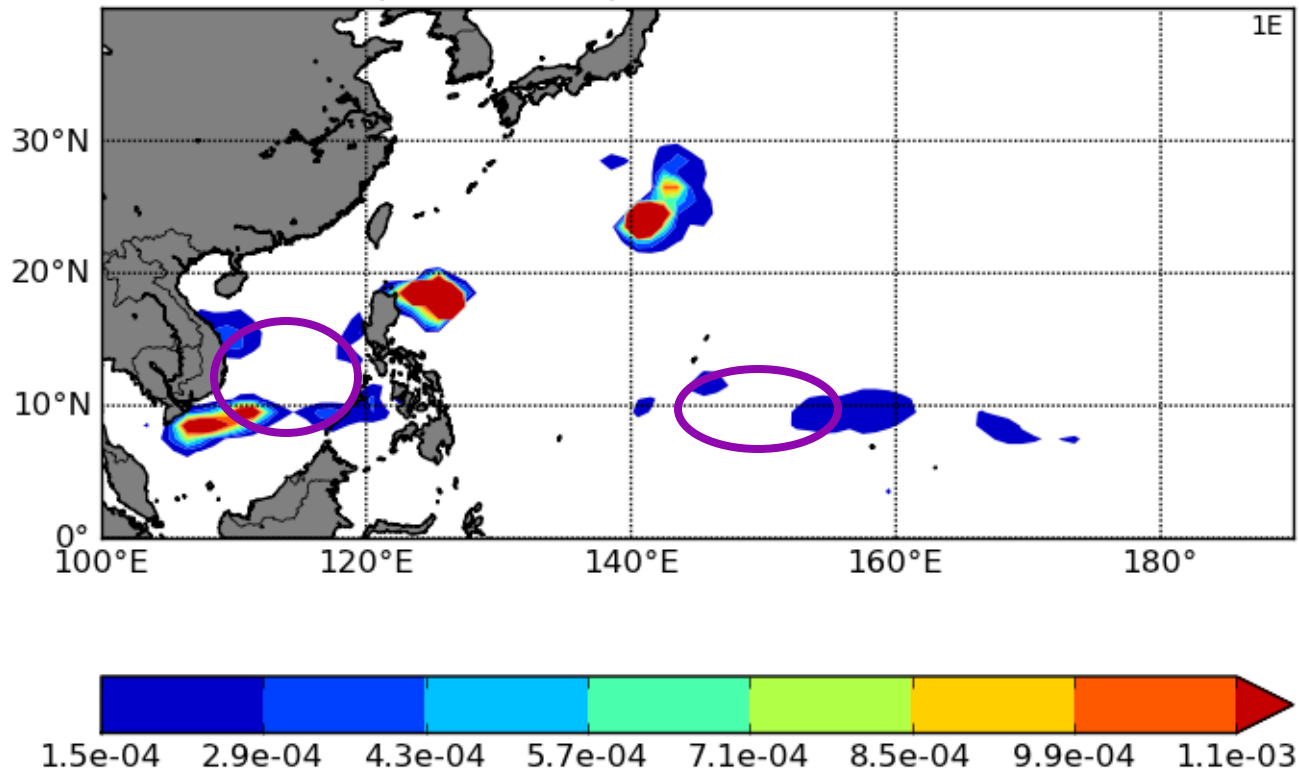






# Multi-Day Lead Information From 1 Day Lead Forecasts

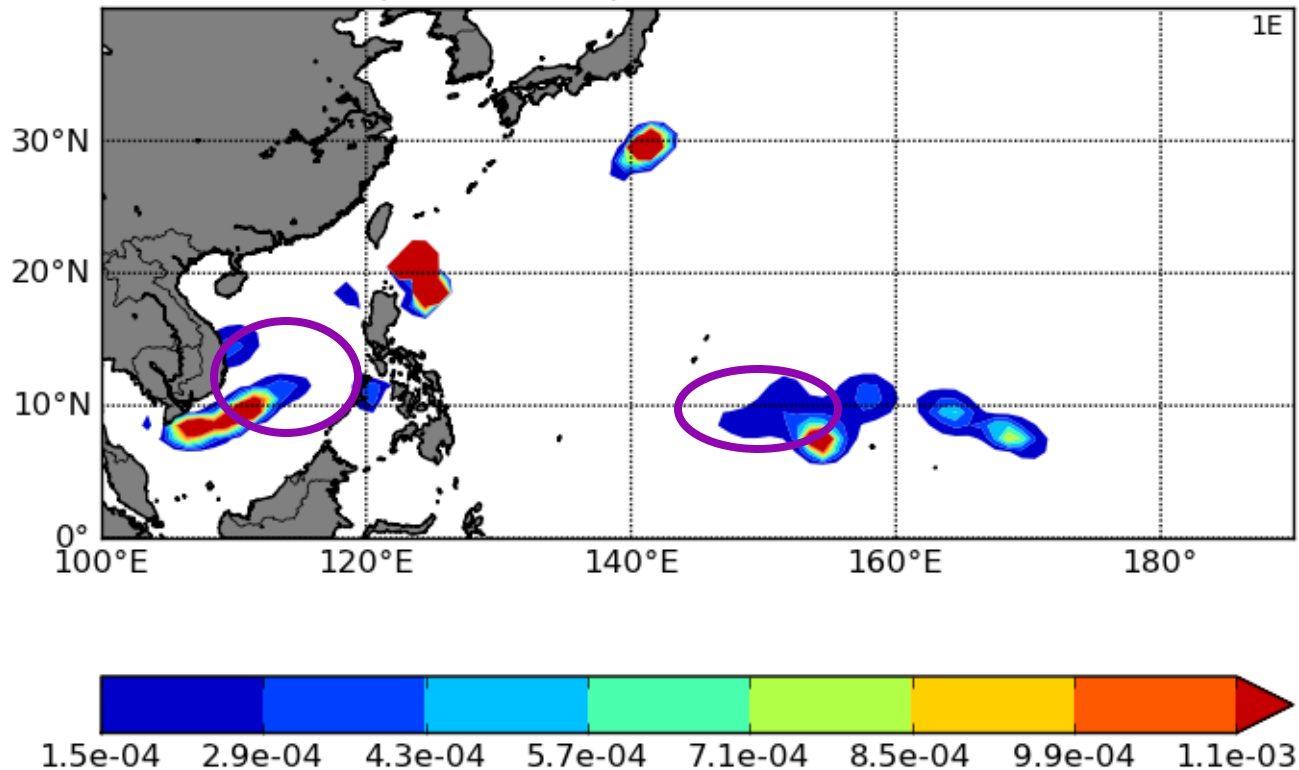
1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20120925, valid:20120926





# Multi-Day Lead Information From 1 Day Lead Forecasts

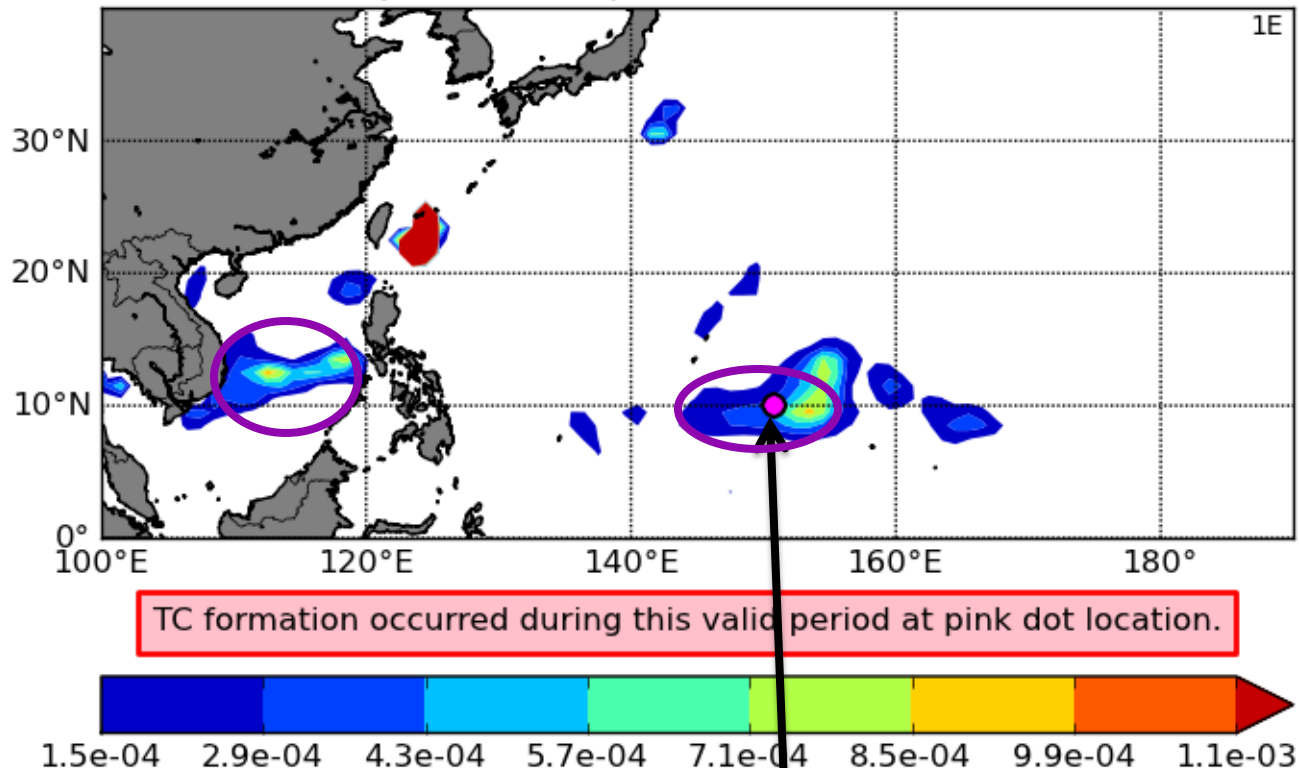
1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20120926, valid:20120927





# Multi-Day Lead Information From 1 Day Lead Forecasts

Hit: 20W, 1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20120927, valid:20120928

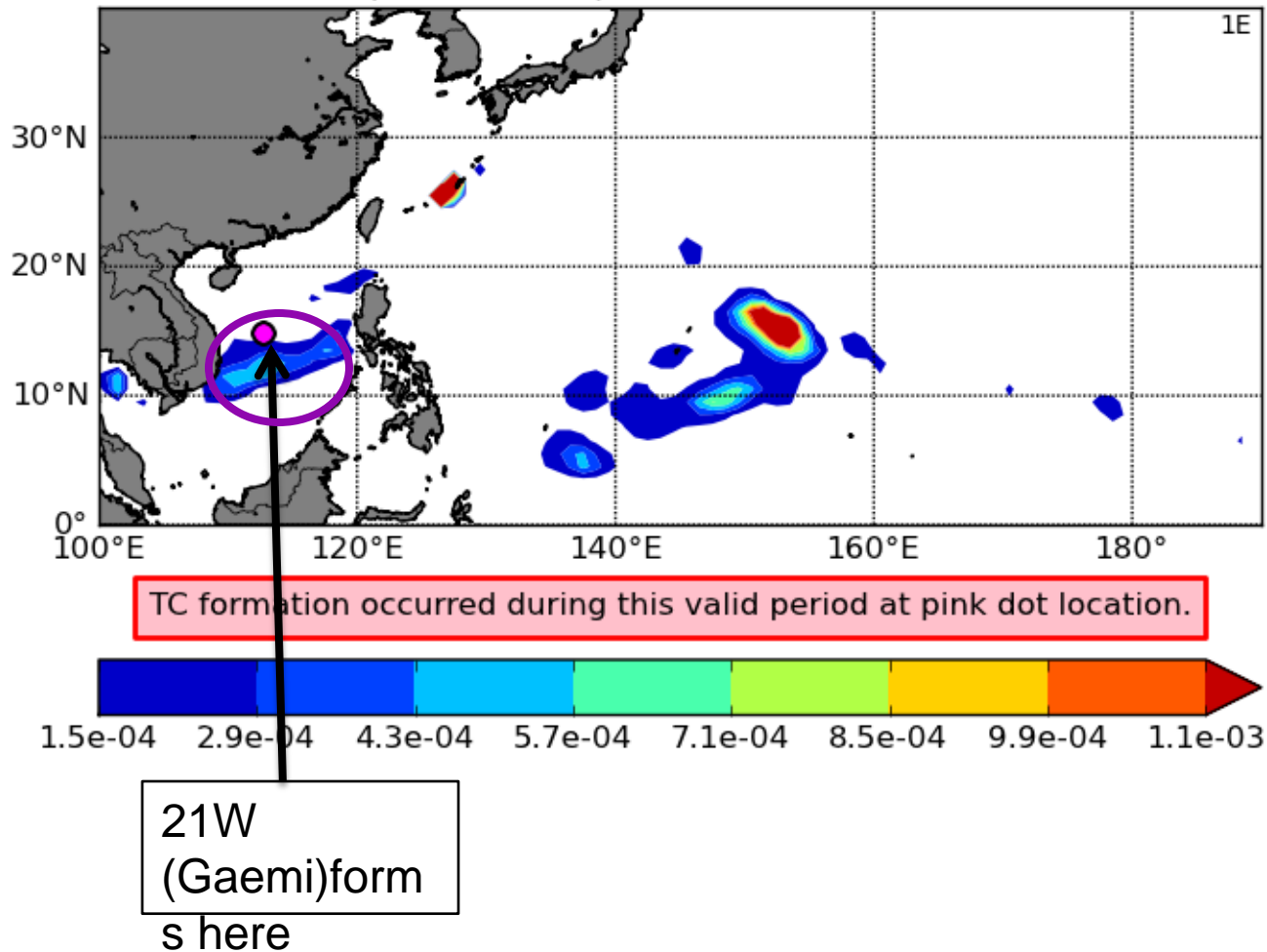


20W  
(Maliksi) forms  
here



# Multi-Day Lead Information From 1 Day Lead Forecasts

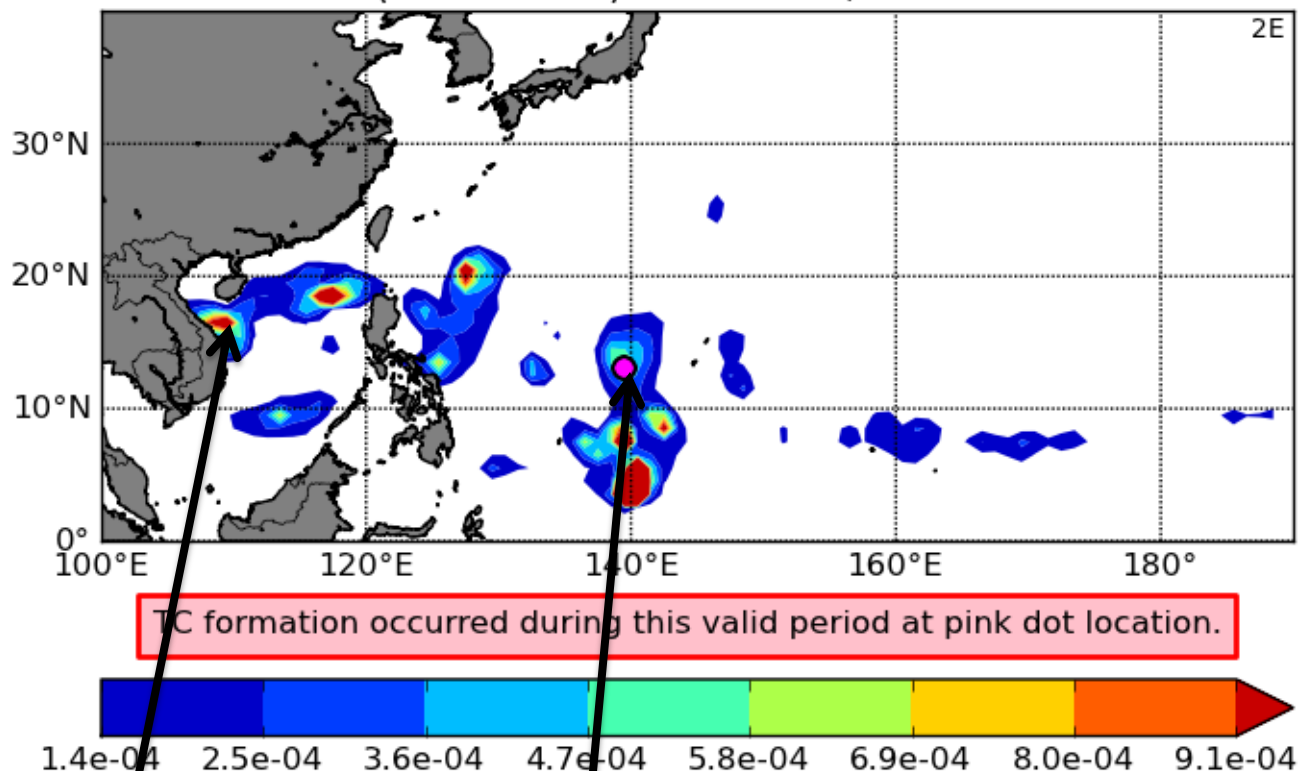
Hit: 21W, 1 day lead TC formation probability forecast, issued (YYYYMMDD): 20120928, valid:20120929





# 4 Day Lead Forecast of TC Formation Probability

Hit: W-20, 4 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20110919, valid:20110923



21W  
(Haitang) will  
form here

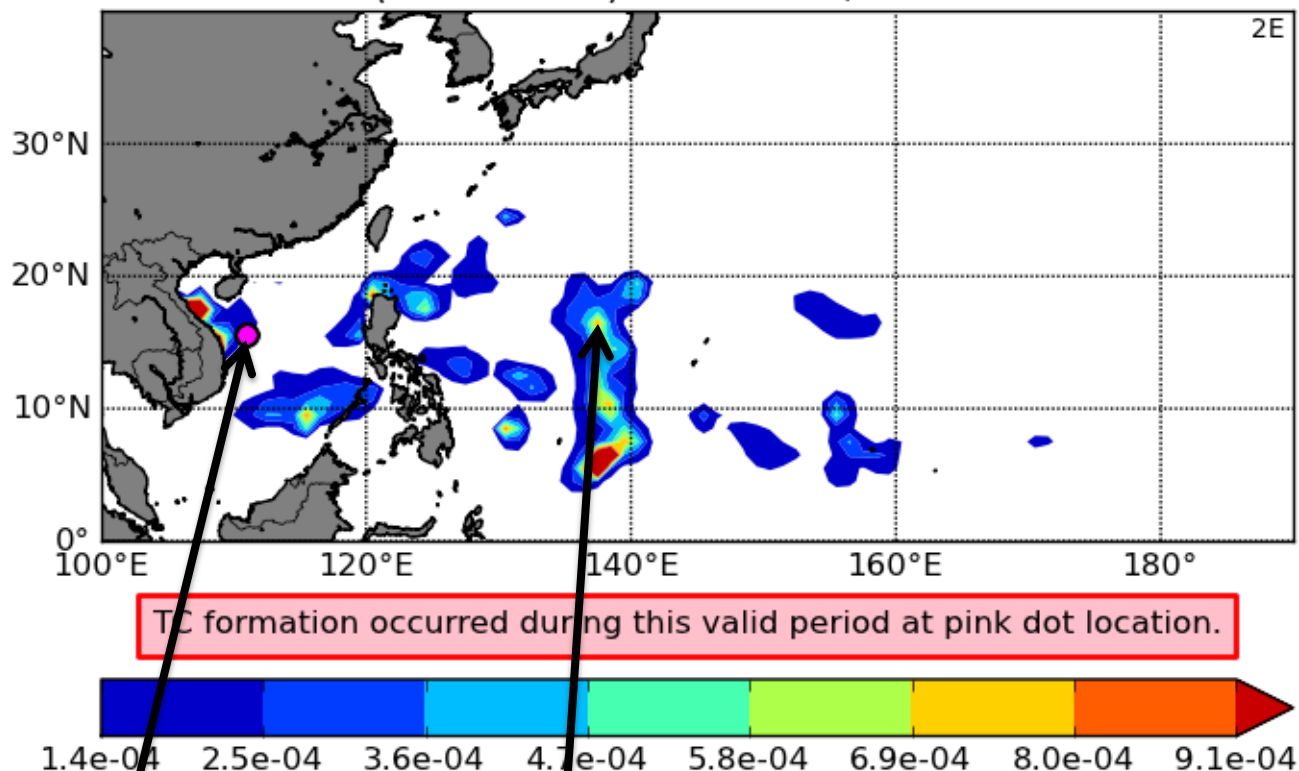
20W  
(Nesat) forms  
here





# 4 Day Lead Forecast of TC Formation Probability

Hit: W-21, 4 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20110920, valid:20110924



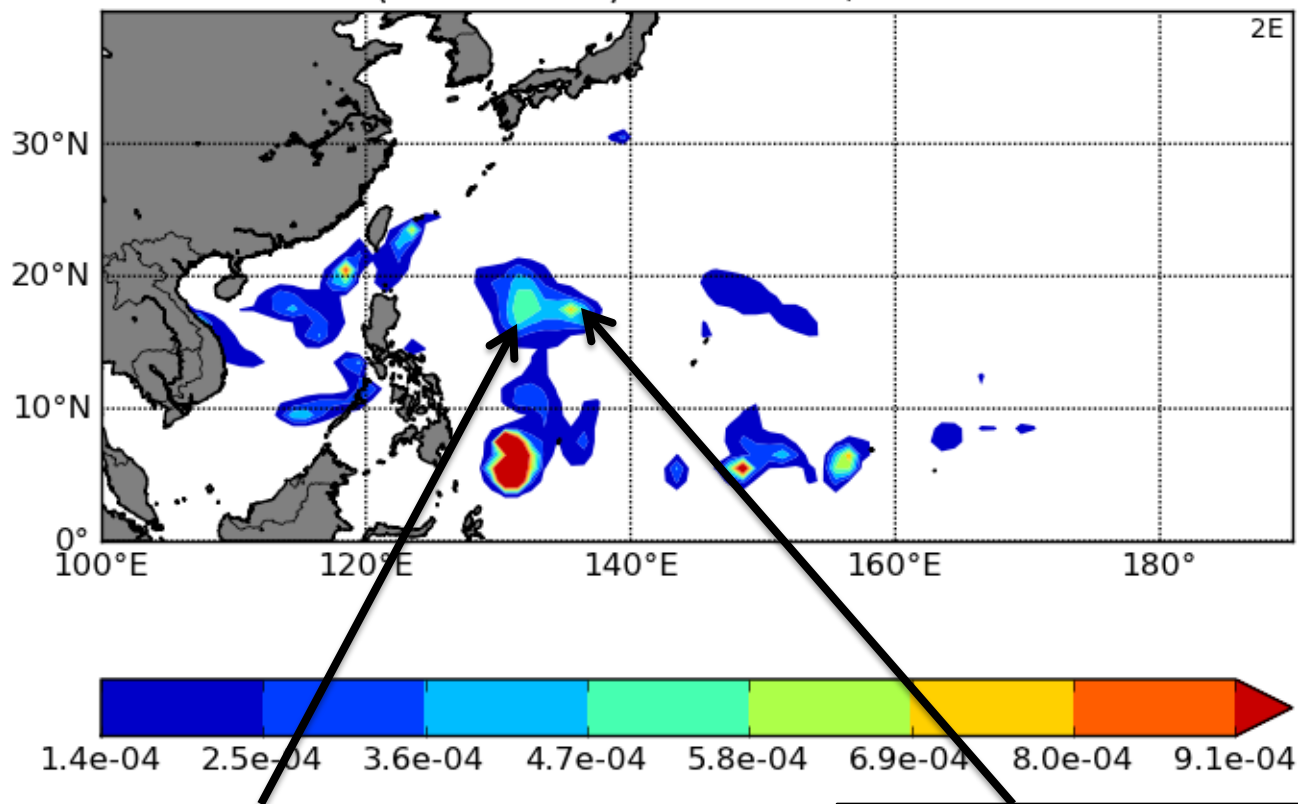
21W  
(Haitang) forms  
here

20W (Nesat) is  
here



# 4 Day Lead Forecast of TC Formation Probability

4 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20110921, valid:20110925



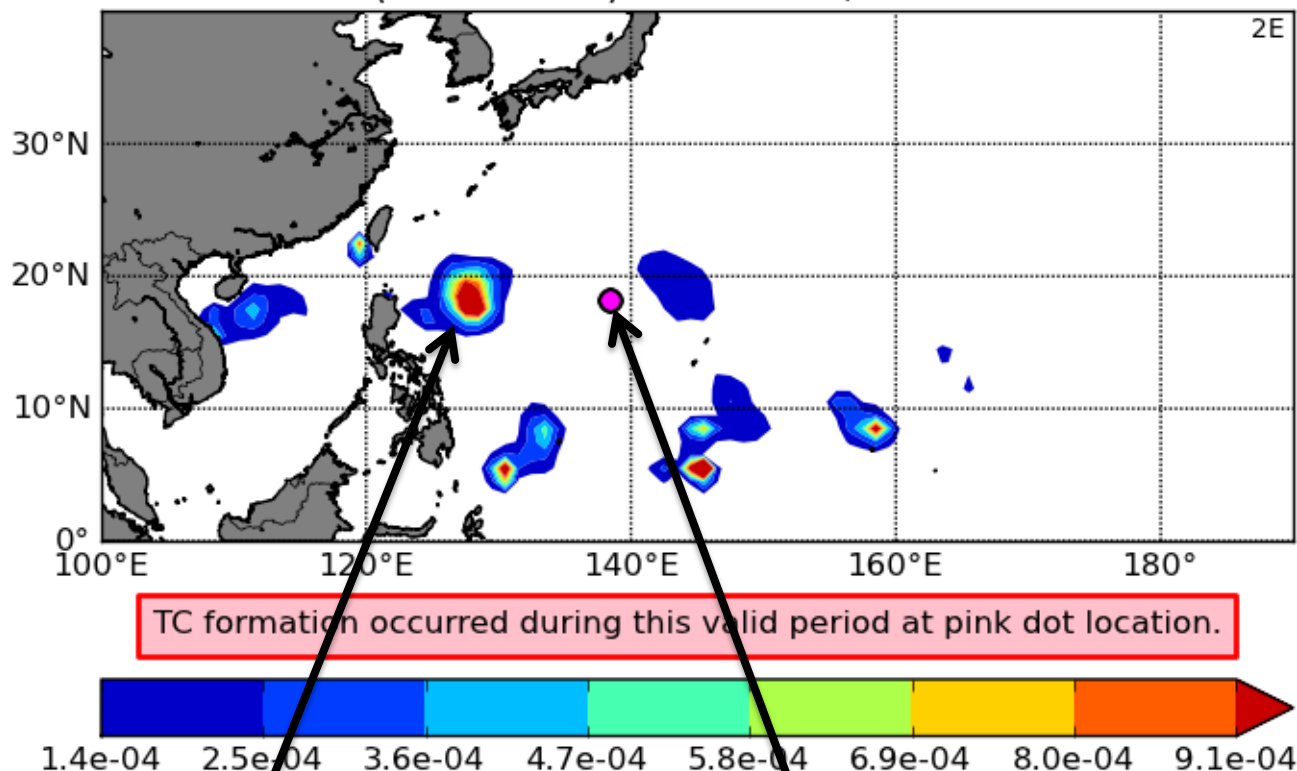
20W (Nesat)  
is here

Favorable conditions  
that lead to the  
formation of 22W  
(Nalgae) on 26 Sep11



# 4 Day Lead Forecast of TC Formation Probability

miss: W-22, 4 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20110922, valid:20110926



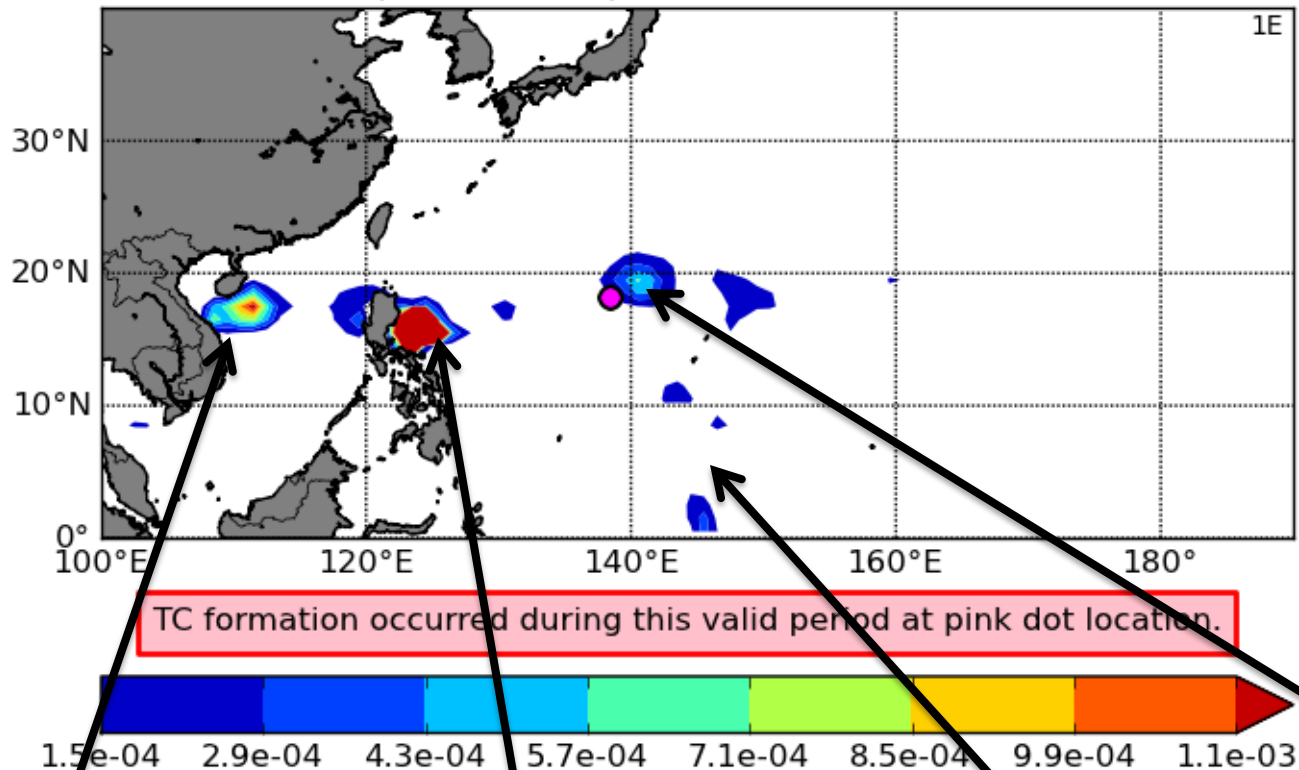
Forecasted  
location of  
21W (Haitang)

22W (Nalgae) forms here,  
favorable conditions are  
forecasted incorrectly in  
time or space or both



# 1 and 4 Day Lead Forecast of TC Formation Probability: A Comparison for the Same Valid Day

Hit: W-22, 1 day lead TC formation probability forecast,  
issued (YYYYMMDD): 20110925, valid:20110926



Compares well  
with 4 day lead

4 day lead forecast  
misplaces location  
of 21W (Haitang)

4 day lead  
forecast over  
predicts here

4 day lead  
forecast slightly  
misplaces  
favorable region



# 4 Day Lead Forecasts of TC Formation Probability

Four day lead forecasts:

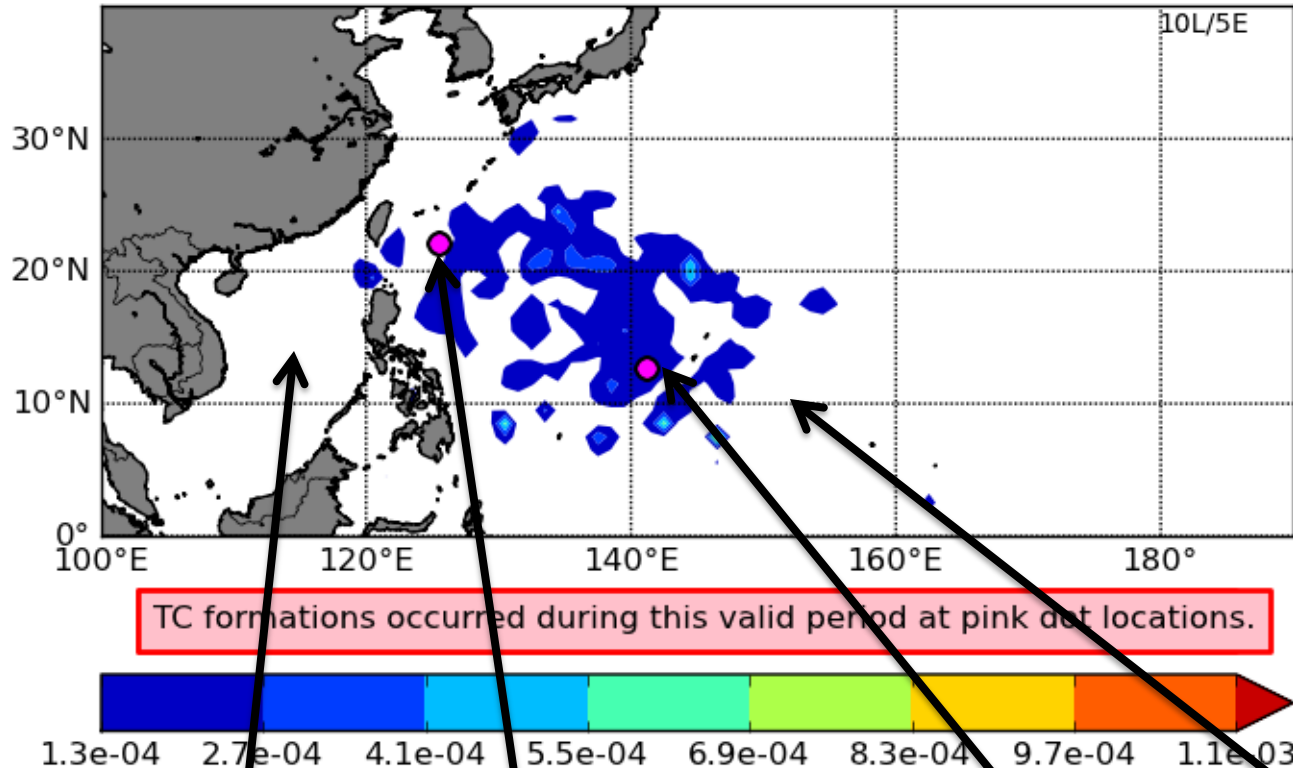
1. Uses two daily (00, 06, 12...) lagged ensemble CFSv2 forecasts (96 and 120 hrs) of the LSEFs
  - a) Ensembling required to improve skill
  - b) Typically our least skilled forecast, but it is the longest lead skilled forecast with a weather pattern look
  - c) Has the expected temporal and spatial errors and sometimes predicts features that will not exist
  - d) The CFSv2 version of this forecast appears to have less error, and requires half the ensembling of the v1 version
  - e) Hits on 34 out of 47 storms (2011-2012)
2. Shared daily with CPC and JTWC
3. The average total area of favorable LSEFs (Jun through Nov, 2011) is only 5.8% of the marine portion of the WNP within 0-30N, 100-180E
4. Forecasts are objective and fully automated





# Week 1 and Week 2 Outlooks of TC Formation Probability

Hit: 15W, Hit: 16W, Week 1 TC formation probability forecast, issued (YYYYMMDD): 20120813, valid: 20120815 - 20120821



Should be active by climatology

15W (Tembin) forms here

16W (Bolaven) forms here

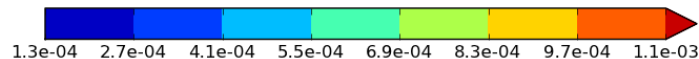
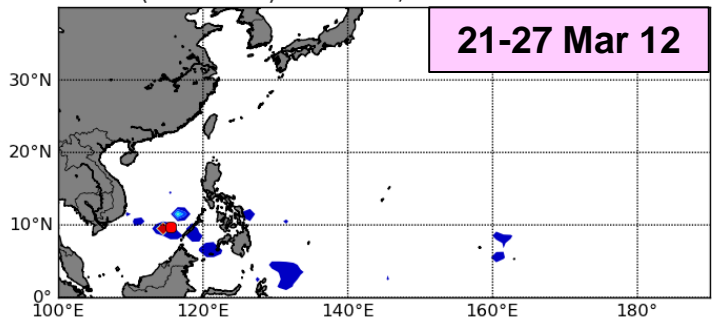
Should be active by climatology



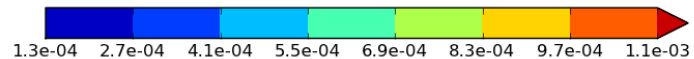
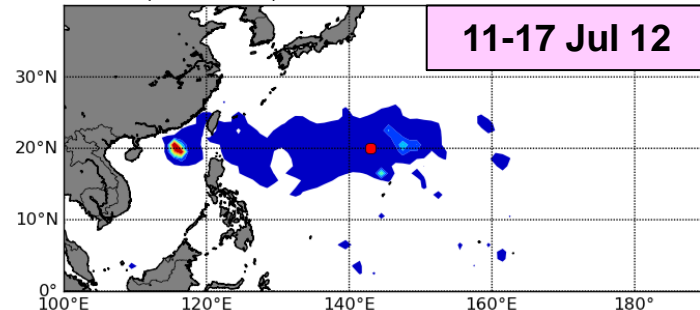
# Weekly Forecast Verification Methods: Qualitative

**Forecasts consistent with climatology and the time of year.**

Hit: W-2, Week 2 TC formation probability forecast,  
issued (YYYYMMDD): 20120312, valid: 20120321 - 20120327

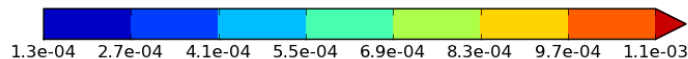
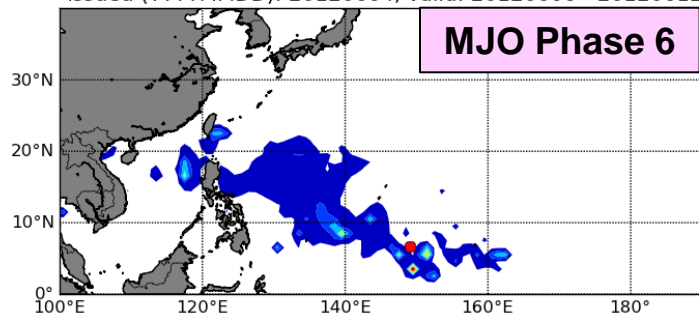


Hit: W-8, Week 2 TC formation probability forecast,  
issued (YYYYMMDD): 20120702, valid: 20120711 - 20120717

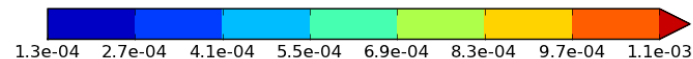
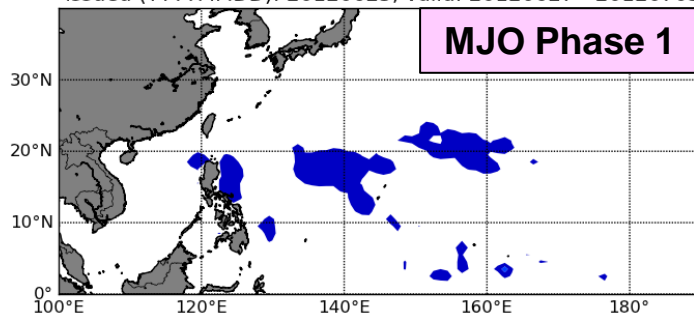


**Forecasts consistent with the MJO phase and ENLN state.**

Hit: W-5, Week 1 TC formation probability forecast,  
issued (YYYYMMDD): 20120604, valid: 20120606 - 20120612



Week 1 TC formation probability forecast,  
issued (YYYYMMDD): 20120625, valid: 20120627 - 20120703





# Week 1 and Week 2 Outlooks of TC Formation Probability

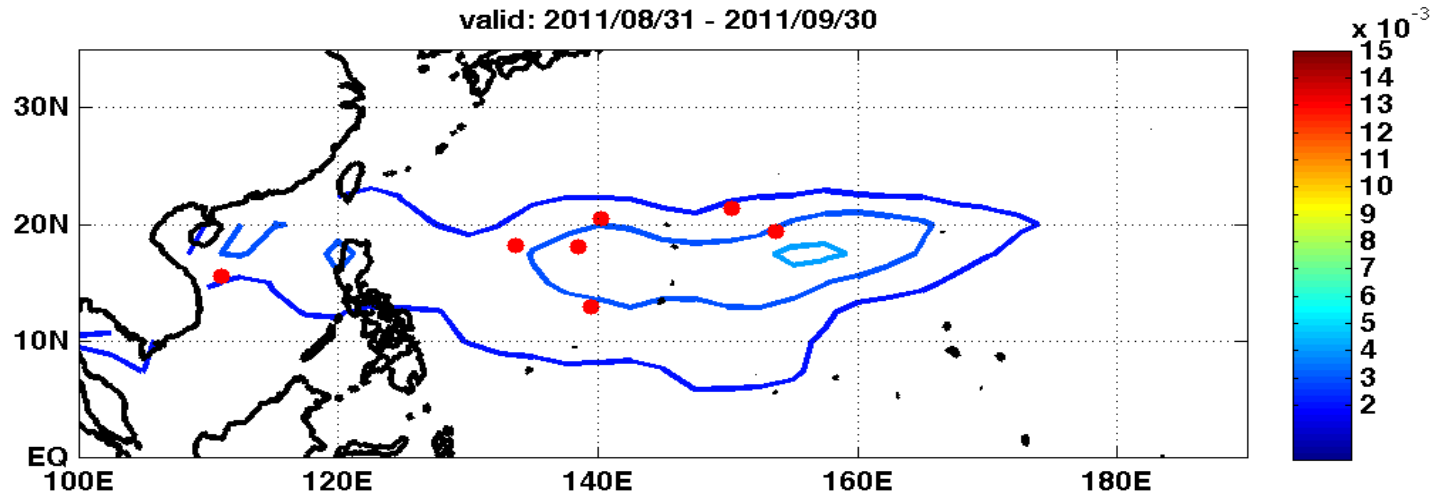
## Weekly Outlooks:

1. Uses 5 daily (00, 06, 12...) lagged ensemble CFSv2 forecasts of the LSEFs to generate a single 10 (week 1) or 17 (week 2) day lead forecast
  - a) 20 ensemble members per daily forecast (compare to 80 for the v1 version)
  - b) Seven consecutive 10 or 17 day lead forecasts are averaged together to form respective weekly outlooks
  - c) 140 ensemble members used per weekly outlook (compare to 1120 for v1)
  - d) Extensive ensembling greatly reduces the weather pattern view, and is more like a composite derived from Monte Carlo simulation
  - e) The CFSv2 version of this forecast requires about one tenth of the ensembling of the v1 version while having comparable skill
  - f) Hits on 38 out of 45 storms (2011-2012)
2. Clear capability to capture the effects of the MJO on TC formation probabilities (never observed with CFSv1 forced forecasts).
3. Likewise, we have observed v2 driven forecasts correctly capturing the effects of Kelvin waves and equatorial Rossby waves.
4. CFSv1 driven forecasts correctly capture the effect of ENLN
5. Shared weekly with CPC and JTWC
6. The average total area of favorable LSEFs (Apr - Nov, 2011) is 13% of the marine portion of the WNP within 2.5-30N, 100-180E, a 25% reduction from v1 forecasts
7. Forecasts are objective and fully automated

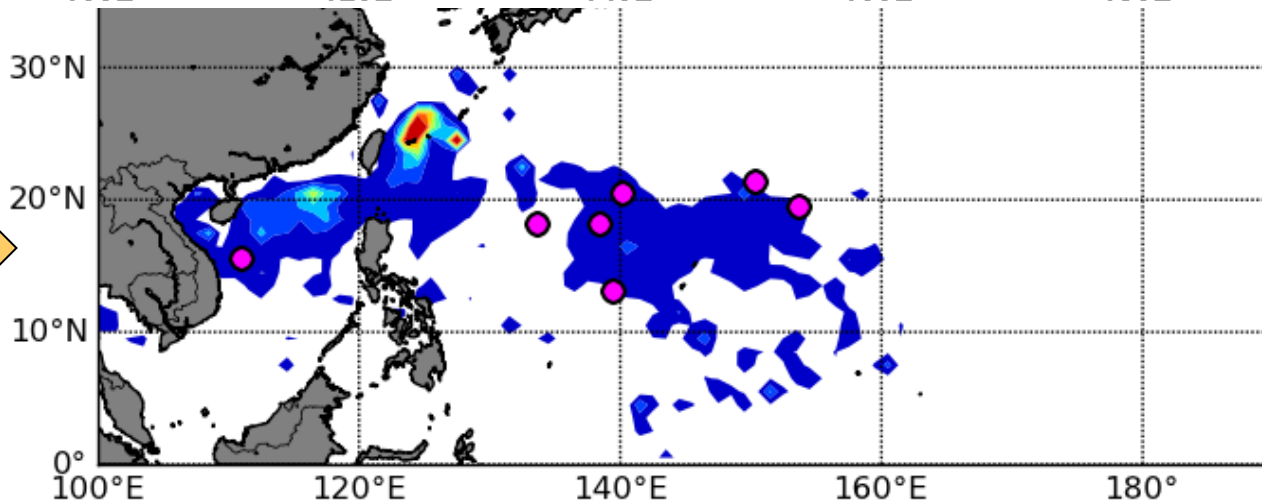


# Extended (monthly) Outlooks of TC Formation Probability

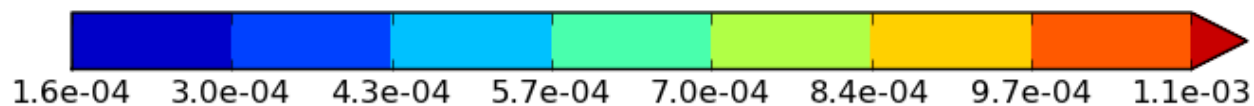
CFSv1  
Forecast



CFSv2  
Forecast



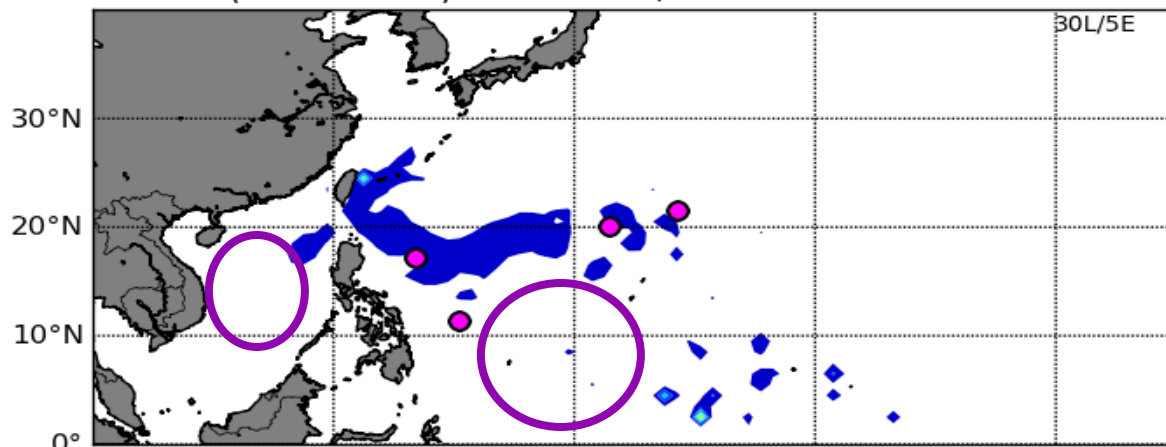
TC formations occurred during this valid period at pink dot locations.



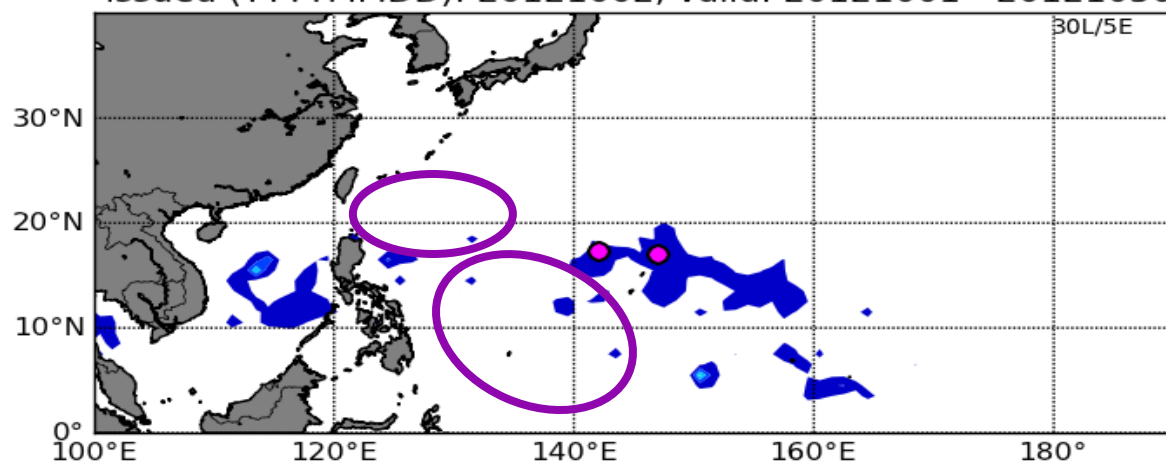


# Extended (monthly) Outlooks of TC Formation Probability

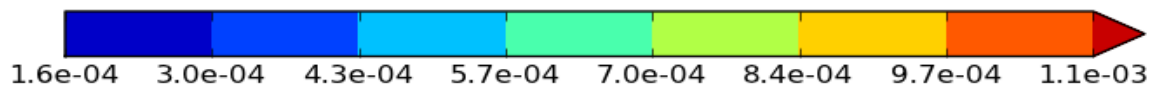
Hit: 08W, Hit: 09W, Miss: 10W,  
Hit: 11W, TC formation probability forecast,  
issued (YYYYMMDD): 20120702, valid: 20120701 - 20120730



Hit: 22W, Hit: 23W, TC formation probability forecast,  
issued (YYYYMMDD): 20121002, valid: 20121001 - 20121030



TC formations occurred during this valid period at pink dot locations.



○ -Indicates region where TC formation would be very unusual by forecast, yet is very active by climatology





# Extended (monthly) Outlooks of TC Formation Probability

## Monthly Outlooks:

1. Uses 5 daily (00, 06, 12...) lagged ensemble CFSv2 forecasts of the LSEFs to generate a single 30, 60, or 90 day lead forecast
  - a) 20 ensemble members per daily forecast (up to 140 for the v1 version)
2. Thirty consecutive 30, 60, or 90 day lead forecasts are averaged together to form monthly outlooks valid for the current month, or at a 1 or 2 month lead
  - a) 600 ensemble members used per 30 day outlook
3. Observed to capture the effects of ENLN (v1)
4. Advantages of the CFSv2 driven monthly outlooks
  - a) Very high POD
  - b) Smaller forecasted area than that forecasted by CFSv1
  - c) Much less ensembling required for comparable skill
  - d) Gives important amplifying details to seasonal forecasts
  - e) Monthly outlook contours actually cover less of the WNP than the weekly forecasts while equaling skill
5. Disadvantages:
  - a) The many contoured regions are awkward to interpret
  - b) Does not have the sensitivity of the weekly forecasts (cannot see the weekly influence of an MJO event)
6. Forecasts are objective and fully automated



# Improvements Made to the NPS TC Forecasting System

**Underway:**

**To be started soon:**

- 1. Adjust minimum contours after 2012 verification**
  - 2. Expand forecast regions to ENP and ATL (preliminary work has been done with promising results)**
  - 3. Take TC intensity forecasting system operational. Preliminary WNP work was very promising**
  - 4. Begin work on TC track forecasting**
- 
- 1. Generate a model index to numerically categorize the likelihood of occurrence in the next week, 2 weeks, month, and up to three months**
    - a) Goal is to further reduce the man in the loop and**
    - b) Create our own seasonal forecasting product based on long lead forecasts of TC formation probability**



# Long Range Forecasting of Tropical Cyclones: Contact Information

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**David Meyer**

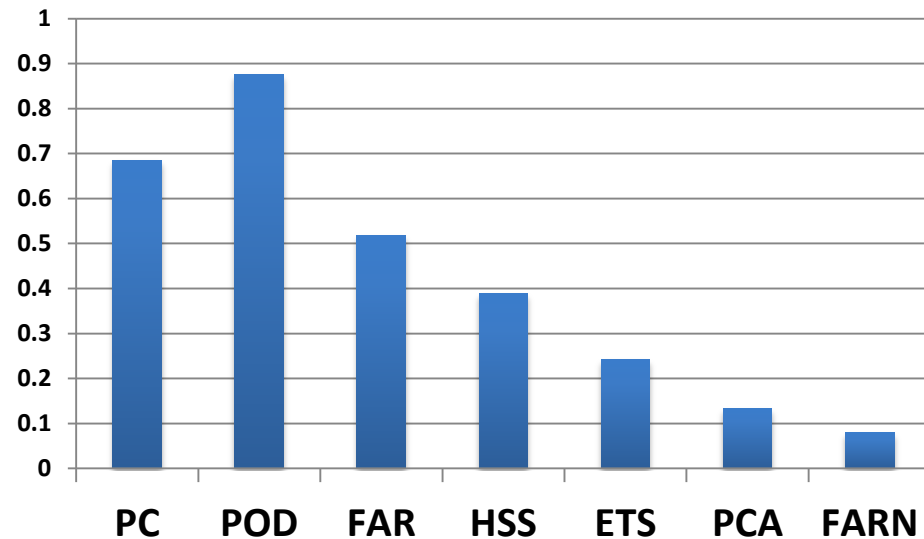
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831-233-8438 cell/office  
[david.statistical.solutions@gmail.com](mailto:david.statistical.solutions@gmail.com)**



# Questions?



# Quantitative Forecasting System Skill Assessment, 30 Day Lead Forecasts, Jun-Nov 2010



1. Performance metrics calculated on a weekly basis for consistency with CPC's weekly GTH forecast
2. A 2.5° neighborhood was used on observations (radius)
3. Weekly outlooks created by averaging 7 days worth of daily 30 day lead forecasts

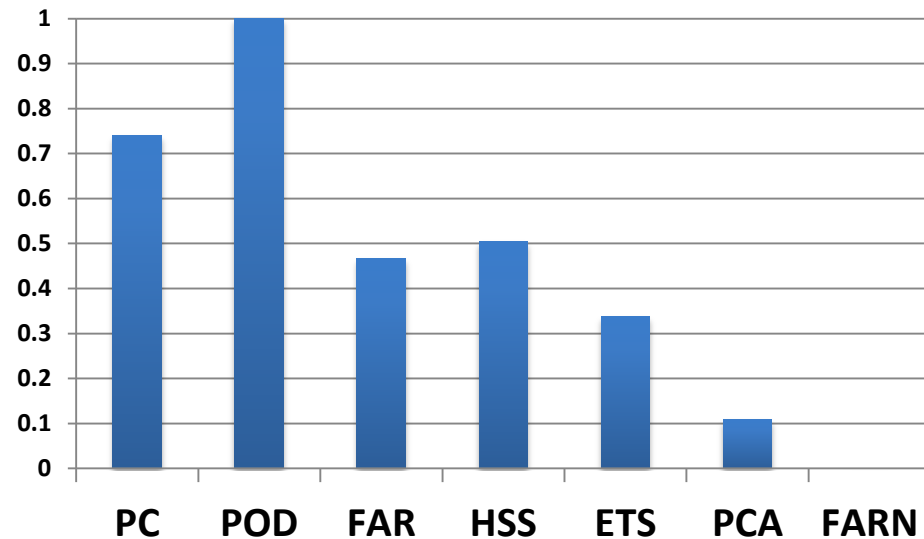
PC: Proportion Correct, POD: Probability of Detection, FAR: False Alarm Ratio, HSS: Heidke Skill Score, ETS: Equitable Threat Score, PCA: proportion of WNP contoured by forecasts, FARN: False Alarm Ratio for forecasted non-formation

1. System performance stability: 2010 performance comparable to 2009 and preliminary 2011 results
2. Additional indicator of good skill: positive Brier Skill Scores
3. No comparable forecasts at these leads available from other sources





# Quantitative Forecasting System Skill Assessment, 60 Day Lead Forecasts, Jun-Nov 2010



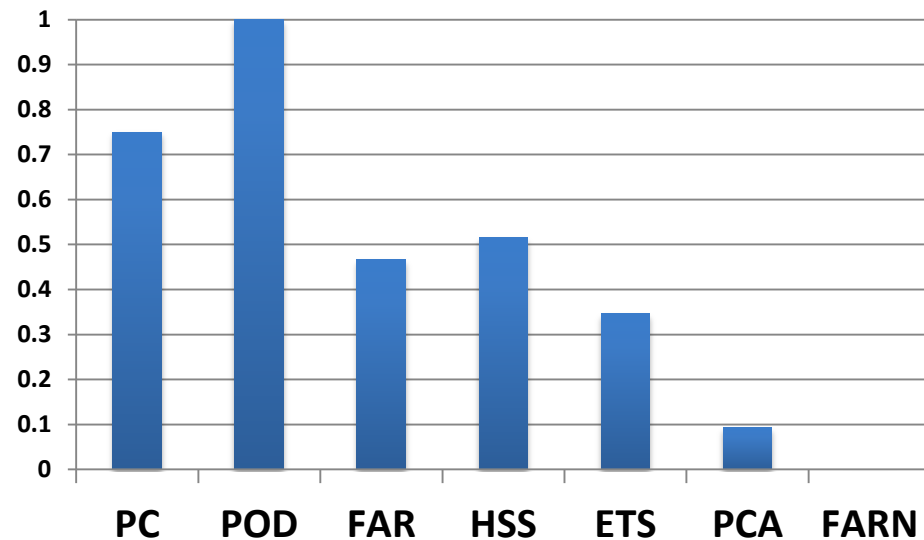
1. Performance metrics calculated on a weekly basis for consistency with CPC's weekly GTH forecast
2. A 2.5° neighborhood was used on observations (radius)
3. Weekly outlooks created by averaging 7 days worth of daily 6- day lead forecasts

PC: Proportion Correct, POD: Probability of Detection, FAR: False Alarm Ratio, HSS: Heidke Skill Score, ETS: Equitable Threat Score, PCA: proportion of WNP contoured by forecasts, FARN: False Alarm Ratio for forecasted non-formation

1. System performance stability: 2010 performance comparable to 2009 and preliminary 2011 results
2. Additional indicator of good skill: positive Brier Skill Scores
3. No comparable forecasts at these leads available from other sources



# Quantitative Forecasting System Skill Assessment, 90 Day Lead Forecasts, Jun-Nov 2010



1. Performance metrics calculated on a weekly basis for consistency with CPC's weekly GTH forecast
2. A 2.5° neighborhood was used on observations (radius)
3. Weekly outlooks created by averaging 7 days worth of daily 90 day lead forecasts

PC: Proportion Correct, POD: Probability of Detection, FAR: False Alarm Ratio, HSS: Heidke Skill Score, ETS: Equitable Threat Score, PCA: proportion of WNP contoured by forecasts, FARN: False Alarm Ratio for forecasted non-formation

1. System performance stability: 2010 performance comparable to 2009 and preliminary 2011 results
2. Additional indicator of good skill: positive Brier Skill Scores
3. No comparable forecasts at these leads available from other sources